Confronting Climate Change in the Gulf Coast Region

Prospects for Sustaining Our Ecological Heritage

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Executive Summary

From Texas to Florida, the Gulf coast region is rich with ecological resources that support the region's economic wealth. Over time, human activities from dam construction to shoreline development have dramatically altered natural landscapes, waterways, and ecological processes. Pressures from human activities remain the most important agents of ecological change in the region today. Over the century ahead, land-use changes are likely to increase as rapid population growth continues. Global climate change, driven by rising levels of carbon dioxide and other heat-trapping greenhouse gases in the atmosphere, will interact with, and magnify, other human stresses on Gulf Coast ecosystems and the goods and services they provide. *Confronting Climate Change in the Gulf Coast Region* explores the potential risks of climate change to Gulf Coast ecosystems in the context of pressures from land use. Its purpose is to help the public and policymakers understand the most likely ecological consequences of climate change in the region over the next 50 to 100 years and prepare to safeguard the economy, culture, and natural heritage of the Gulf Coast. This summary highlights key findings.

What is the likely climate future for the Gulf Coast region?

Projecting climate changes for the Gulf Coast is challenging because of the complex interplay of regional and global processes that drive the climate here and the natural variability in air and sea-surface temperatures, rainfall, and hurricane activity the region experiences. Nevertheless, the two climate scenarios used in this report both predict warmer temperatures and an increase in the rate of sea-level rise over the next 100 years. Summer high temperatures are projected to rise between 3 and 7°F and winter low temperatures to warm by as much as 5°F to the east and 10°F to the west. This would bring a dramatic increase in the July heat index along the Gulf Coast and a significant decrease in winter cold spells, as well as a northern shift in the frost line.

Global sea-level rise will have a disproportionate effect along the Gulf Coast shoreline because of its flat topography, regional land subsidence, extensive shoreline development, and vulnerability to major storms. Climate models project sea-level rise along the Gulf Coast ranging from over 8 to almost 20 inches in the next century. Taking regional subsidence into account, the relative sea-level rise over the next 100 years could range from 15 inches along most of the Gulf Coast to as much as 44 inches along the Louisiana/Mississippi Delta.

Considerable uncertainty remains about whether the regional climate will become wetter or drier in the future. Because future trends in rainfall, runoff, and consequent soil moisture are critical to human and ecological well-being in the Gulf Coast, we believe the most prudent approach is to assess the potential impacts of both scenarios. Changes in vital climate-related phenomena such as stream flow and wildfire frequency will depend on the balance of rainfall received and moisture lost to evaporation in a warming climate in conjunction with human intervention and management. In major rivers such as the Mississippi, water flows will be determined by rainfall trends in watersheds far upstream from the Gulf Coast, as well as by massive human-engineered flood control structures.

Other vital but difficult to predict climate-driven changes include potential shifts in El Niño/La Niña cycles, hurricanes, storms, and coastal ocean currents. Even if storm intensities remain constant, however, disturbance from coastal flooding and erosion will increase because rising sea levels will generate higher storm surges even from minor storms.

What might these changes mean for Gulf Coast ecosystems and the goods and services they provide?

The ecological impacts of climate change will have important implications for the health and well-being of human populations as well as other goods and services that ecosystems provide to society. Global warming will have particularly important impacts on the region's water resources. Gulf Coast ecosystems are linked by the flow of water from the uplands through freshwater lakes, rivers, and wetlands to the coastal and marine systems downstream. Vast wetland areas, especially in the central and eastern parts of the region, require periods of flooding to maintain healthy habitats and sustain food webs. While there remains uncertainty about how global warming will affect rainfall, stream flow, soil moisture, and overall water availability, human consumption of water resources is almost certain to increase as a result of the region's population growth. If climate change results in reduced runoff and lower groundwater levels for parts of the year, the consequence could be a shortage of water to satisfy both ecosystem needs and the growing and competing human demands. Besides direct water shortages, the range of impacts could include the following:

- Permanent reductions of freshwater flows in rivers from both human activities and climate change could substantially reduce biological productivity in Mobile Bay, Apalachicola Bay, Tampa Bay, and the lagoons of Texas.
- More frequent or longer lasting droughts and reduced freshwater inflows could increase the incidence of extreme salt concentrations in coastal ecosystems, resulting in a decline of valuable habitats such as the mangroves and seagrasses in Florida Bay or South Texas lagoons.
- A drier climate along the Gulf Coast combined with such activities as dredging, constructing reservoirs, diverting surface water, and pumping groundwater could accelerate local subsidence and sinkhole formation in areas underlain by limestone.
- Changes in soil moisture could shift forest dynamics and composition. For instance, natural pine forests can tolerate lower soil moisture than oak-pine and oak-gum forests.

- The oxygen-poor (hypoxic) waters in the Gulf of Mexico off Louisiana now extend over as much as 8,000 square miles, depending on the amount of nitrate-laden fresh water discharged by the Mississippi River. The complex interaction of nutrient load and amount of runoff make future projections challenging. A 20 percent increase in discharge—as some climate models project—could increase the risk of hypoxia and expand the oxygen-poor "dead zone."

Sea-level rise will also affect the availability and distribution of high-quality fresh water because many Gulf Coast aquifers are susceptible to saltwater intrusion. Sea-level change and coastal storms are naturally occurring phenomena that help shape coastal ecosystems. However, these episodic disturbances, coupled with high rates of land subsidence and increasing human impacts on the coastal environment, will lead to further degradation in coastal ecosystems and damage to human communities. For example:

Native plants and animals, already stressed and greatly reduced in their ranges, could be put at further risk by warmer temperatures and reduced availability of fresh water.

- The increasing drawdown of surface water systems and underground reservoirs could combine with sea-level rise to increase saltwater contamination of aquifers, particularly near the coast and in large urban areas such as Tampa and Houston.
- Drinking water supplies taken from the Mississippi River for coastal communities such as New Orleans will be more frequently threatened by saltwater intrusion caused by a combination of sea-level rise, land subsidence, and periodic low river flows.
- Wetland loss rates over the next 20 years in coastal Louisiana, due to the combination of sea-level rise and human alterations, will continue to convert land to open water, threatening the region's enormously valuable fisheries, aquaculture and coastal agriculture, as well as navigation and other industries located near the coast. Future wetland loss rates could increase as sea-level rise accelerates in the latter part of the 21st century.
- As a result of human development, interactions of sea-level rise with hurricanes will increasingly disrupt the normal landward migration of barrier islands and contribute to their erosion.
- Whether or not global warming increases the number or intensity of hurricanes, future storm damages are likely to rise substantially because of the increasing amount of development in harm's way and the aggravating impacts of higher sea levels and degraded coastal ecosystems. Predictions of future wave and storm surges accompanying severe hurricanes (categories 3–5) indicate that significant wave heights (between 3 and 6 feet) could reach further inland if barrier islands and wetlands are lost as buffers.
- The coastal systems most vulnerable to sea-level rise include freshwater marshes and forested wetlands in subsiding delta regions, mangroves in limestone areas, coastal marshes with human-altered patterns of water flow, and areas with extensive human development.

Climate changes such as warmer temperatures, fewer freezes, and changes in rainfall or storm frequency will tend to shift the ranges of plant and animals species and alter the makeup of biological communities. With increasing temperature, many invasive tropical species are likely to extend their ranges northward. Native plants and animals, already stressed and greatly reduced in their ranges, could be put at further risk by warmer temperatures and reduced availability of fresh water. The range of potential impacts on species and ecosystems include the following:

- Species that are already endangered such as the Cape Sable seaside sparrow and Florida panther could become more vulnerable as their preferred habitats change or shift with global warming. Current water-management practices and human development create additional challenges for species migration and adaptation.

- In the Big Thicket area of East Texas, known as "the American Ark," diverse forest communities could be threatened by altered growth rates, changes in fire frequency, and intensified invasions by nonnative species such as Chinese tallow trees.
- Extensive open grassland and forest areas in South Texas and South Florida could become more vulnerable to damaging invasion by Chinese tallow trees. Those in South Florida could in addition be threatened by melaleuca and casuarina trees.
- Coastal red mangrove communities might shift further to the north on the Florida and Texas Gulf Coast. Along the Louisiana coast, reduced frost frequency would allow expansion of black mangrove forests.
- Coral reefs off the South Florida coast already endure summer sea-surface temperatures near their maximum tolerance and face heat stress during episodes of elevated temperature, such as those that accompany El Niño events. Rising ocean temperatures will exacerbate that stress.
- In freshwater streams, warmer water temperatures and a longer growing season could reduce habitat for cool-water species, particularly fish, insects, snails, and shellfish. In very shallow water systems, higher temperatures could lead to oxygen-depletion and cause potentially massive die-offs of fish and invertebrates.
- Invasive species threaten both freshwater and coastal aquatic ecosystems, affecting native plants, fish, and shellfish and associated commercial and recreational fisheries.

Climate change will also indirectly affect natural and managed landscapes by changing the intensity and frequency of fires and pest outbreaks. For example:

- Most southern pine plantations are not burned regularly because of management costs and legal liabilities, despite awareness of the need to reduce fuel loads. High fuel loads increase the risk of wildfire, especially if the climate becomes more favorable to intensified fire cycles.
- Increases in drought-related fires would have severe impacts on managed forests and the timber-based economy of the region. Wildfires would also pose substantial risks to nearby human development.
- In contrast, wildfires are critical for maintaining grassland communities such as coastal prairies, and woody plants typically invade prairies that are not mowed or burned. Increased fire frequency should help prairie conservation and the maintenance of grazing lands.
- Warmer average temperatures and milder winters are likely to result in a higher incidence of damage by agricultural and forestry pests such as the Southern Pine bark beetle.

Plant growth and productivity could increase with higher atmospheric concentrations of carbon dioxide (CO_2) and modestly warmer temperatures, as long as rainfall is not reduced. However, increased plant growth in response to higher CO_2 varies among species and higher CO_2 could drive changes in the mix of species and interactions within communities. Further, gains in plant productivity due to increased CO_2 could be countered by other climate-driven changes such as reduced moisture availability, higher ultraviolet-B radiation, limited nutrient availability, increased water stress, increases in pests and fires, and air pollution. For example:

Climate change will affect natural and managed landscapes by changing the intensity and frequency of fires and pest outbreaks.

- Certain agricultural crops such as corn, sorghum, and rice could become more productive due to higher CO_2 concentrations, assuming other stresses do not counter the fertilizer effects of CO_2.
- If the climate of the Gulf Coast turns drier overall, cotton, soybean, rice, and sorghum productivity could drop without irrigation and citrus production may shrink moderately in Florida.

Global warming will also increase some health risks in the Gulf Coast region. The ability of the health care system to reduce these health risks in the face of climate change, however, is an important considera-

tion in any projections of vulnerability during the 21st century.

- The concentration of air pollutants such as ozone is likely to increase in Gulf Coast cities such as Houston and Galveston. These and other metropolitan areas are already now classified in "severe" noncompliance with federal air quality standards. Ground-level ozone has been shown to aggravate respiratory illnesses such as asthma, reduce lung function, and induce respiratory inflammation.
- Texas is particularly vulnerable to increased frequencies of heat waves, which could increase the number of heat-related deaths and the incidence of heat-related illnesses. However, longer periods of extreme heat can cause problems throughout the region, especially among the ill or elderly and people who cannot afford air conditioning.
- Gastrointestinal diseases, respiratory diseases, and skin, ear, and eye infections can result from eating contaminated fish and shellfish and diseases acquired during the recreational use of coastal waters. Since temperature, rainfall, and salinity all influence the risk of waterborne infectious diseases, this risk may increase with climate change.
- Hotter temperatures, extreme rainfall, and increased runoff can increase populations of disease-carrying insects and boost the potential for transmission of diseases such as malaria and dengue fever. But actual incidences of these diseases will depend primarily on the responsiveness of the public health system and on the adequate maintenance of water-related infrastructure.

How can residents of the Gulf Coast region address the challenge of a shifting climate?

To prevent or minimize the negative impacts and profit from the potential benefits of climate change, citizens and policymakers in the Gulf Coast region can and should take action now. Three basic strategies —mitigation, minimization, and adaptation—can reduce the region's vulnerability to the impacts of climate change and yield significant ecological, economic, and health benefits, even in the absence of major climate disruption. We consider them a prudent and responsible approach to ensuring environmental stewardship of the region's invaluable ecological resources. Because much of the region is held in private land ownership, strategies for dealing with both climatic and human stresses on ecosystems must involve private landowners as well as governmental agencies and other sectors of society.

The primary goal of mitigation is to reduce the magnitude of climate stresses on society and ecosystems. Reducing greenhouse-gas emissions, for instance, can be seen as a type of "insurance policy" that aims at directly reducing the risks of global warming. Clearly, in the Gulf Coast region, where the fossil-fuel industry is the biggest economic sector and where greenhouse-gas emissions are among the highest in the nation, it is critical to find ways to reduce greenhouse-gas emissions without reducing the economic vitality of Gulf states. For example, investment in the region's substantial renewable energy resources (e.g., solar, wind, and biomass) could provide incentives for new technology development and economic diversification while reducing air pollutants and greenhouse gases.

The second strategy is to reduce human disturbances and destruction of ecosystems. Employing "best practices" in land and resource use can minimize ecologically harmful side effects while continuing to provide significant, and often increased, economic benefits. For example, progressive zoning initiatives that integrate different land uses over a smaller area can protect natural resources and open space from suburban sprawl. Wise land-use practices can also help manage coastal areas, and best management practices in agriculture and aquaculture can achieve goals such as water conservation and reduced farm runoff.

Finally, Gulf Coast residents, planners, land managers, and policymakers can act now to minimize the potential impacts of global climate change and better prepare the region to deal with an uncertain future. One of the best ways to deal with uncertainty is to adopt learning-oriented, flexible approaches that include monitoring, periodic review, and adjustment of previous decisions in light of new information—a strategy known as adaptive management. The principal targets for adaptation include water resource management, agriculture and forestry, land and biodiversity conservation, and preparation of coastal communities to respond to sea-level rise and severe coastal storms such as hurricanes.

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In addition, much must be done in the Gulf Coast region to raise awareness and understanding of global climate change. This can begin by educating people of all ages about the cultural and ecological heritage at stake. But it must also involve educating them about the fundamentals of ecology and climate, and what drives them to change. Many Gulf residents' livelihoods are inextricably linked to its natural resources, and visitors from around the world come to the Gulf to enjoy and learn about its ecological heritage. Raising people's concern and understanding of climate change would help to mobilize public support for climate protection. This report is intended to begin that process by sketching the scope of the potential impacts of global warming and starting a dialogue about the management and policy choices that will help preserve the Gulf Coast region's ecological and economic wealth.